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(54) **An electric machine**
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Machine électrique

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EP-A- 0 630 097 **US-A- 5 424 624**

- **LE-HUY H ET AL: "UNIPOLAR CONVERTERS FOR SWITCHED RELUCTANCE MOTORS" CONFERENCE RECORD OF THE INDUSTRY APPLICATIONS SOCIETY ANNUAL MEETING. (IAS), SAN DIEGO, OCT. 1 - 5, 1989, vol. PART 1, no. CONF. 24, 1 October 1989, pages 551-560, XP000091616 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS**

EP 0 843 405 B1

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Description

[0001] The invention relates to an electric machine and in particular to a position detector for an electric machine. The invention is particularly, although not exclusively, applicable to switched reluctance (SR) machines.

[0002] The general theory of design and operation of switched reluctance machines is well known. It is discussed, for example, in "The Characteristics, Design and Applications of Switched Reluctance Motors and Drives" by Stephenson & Blake, presented at the PCIM '93 Conference and Exhibition at Nürnberg, Germany, June 21-24, 1993.

[0003] The switched reluctance drive is a variable-speed drive system comprising a switched reluctance machine supplied from a power-electronic converter under the control of low-power control electronics. The motor has salient poles on both the stator and the rotor, typically with an excitation coil around each stator pole. These stator coils are grouped to form one or more phase windings. The electrical currents in the windings are typically switched on and off by power-electronic switches. It will be appreciated that the reluctance machine can be operated equally well as a motor or a generator.

[0004] Fig. 1 shows a schematic diagram of a typical 3-phase SR machine, which has six stator poles and four rotor poles. The radially opposed poles carrying windings A and A' (phase A) have opposite magnetic polarisation determined by the arrangement of the windings. Phases B and C are formed similarly.

[0005] The timing of the switching of the currents in the windings is controlled according to the relative angular positions of the stator and rotor poles. This relative position may be detected by a rotor position transducer (RPT) consisting of a rotating member and stationary sensors which supply signals to the control electronics.

[0006] Those skilled in the art will recognise that there are many known forms of RPT, including, e.g., that shown in EP 0630097.

[0007] The RPT is used to ensure that the currents of the phase windings are switched on and off at the appropriate angles of rotation. Fig. 2 illustrates a typical system consisting of a rotating slotted disc and three optical sensors which are switched by the rotation of the disc.

[0008] The RPT typically consists of a vane on the rotor which interrupts one or more slotted optical switches each comprising a light emitting diode (LED) and a phototransistor. Typically, it is necessary to supply the LED with current of the order of 10-20mA in order for the slotted switch to operate.

[0009] Figure 3 shows part of a typical converter circuit for a switched reluctance machine. The rectifier bridge 8 supplies the dc link 6 from a single phase alternating current supply 4. A dc link capacitor 5 acts to smooth the voltage of the dc link.

[0010] One known arrangement for supplying current to the LED is also-shown in Fig. 3. The arrangement shown is of the "resistive dropper" type commonly used in drives which are designed for cost-sensitive applications such as washing machines, vacuum cleaners, dishwashers etc. A slotted optical switch is shown generally at 10 and includes an LED 12 and a cooperating phototransistor 14. The phototransistor 14 outputs a signal along lines 16 to a control system of any suitable known type to control the switching of the currents in the windings according to the RPT signal. The LED 12 supply current is provided by a resistor, or plurality of resistors 18, connected in series to the DC bus.

[0011] In systems designed for $120V_{AC}$ utility supplies, the provision of 20mA of LED current causes a nominal dissipation in the resistors 18 of over 3W. In systems designed for $230V_{AC}$ supplies, the nominal dissipation rises to over 6W. Provision of a 3W or 6W rated resistor uses valuable printed circuit board area and adds to the heat dissipation requirement of the electronics system. Furthermore, especially in domestic applications, such systems are generally required to operate over a wide supply range, varying between for example $100V_{AC}$ and $132V_{AC}$. When the (fixed) resistors 18 are used to derive the LED 12 current, the magnitude of the current can vary significantly from the optimum. In fact it is often necessary to use a conventional power resistor having a significantly higher power rating in order to achieve certification as to the flammability of a product in the domestic appliance market, thus further adding to cost. It will be seen, therefore, that various problems arise in conventional power supply arrangements for the optical switch 10.

[0012] It is an object of the present invention to avoid or at least mitigate some of the problems set out above.

[0013] According to the invention there is provided an electric machine as defined in claim 1 and a method of providing current to another circuit in an electric machine as defined in claim 8. Some preferred features are recited in the dependent claims. The other circuit may comprise an element, or all, of a position sensor for sensing the position of the moving part relative to the stator part.

[0014] A dedicated independent supply is not required for the position sensor.

[0015] As a result, variations in the main power supply rating do not affect the position sensor, hence enabling reduced power dissipation and allowing correspondingly lower power rated resistors to be used. Voltage maintaining means, for example a capacitor or a capacitor and a resistor in series, may be provided in parallel with the voltage setting means. The voltage setting means may comprise a zener diode. The zener diode, when conducting, provides a constant reference voltage for the position sensor. When the zener diode is off, the capacitor substantially maintains the constant voltage until the zener diode conducts again.

[0016] The electric machine may comprise a multi-phase electric machine having respective current energisable means associated with each phase, wherein the current drivable component of the position sensor is provided in a common current path with each current energisable means. As a result the position sensor is energised by successive phases, allowing use of a capacitor of reduced value.

[0017] The method may comprise switching the current energisable means to a free-wheeling state and switching a portion of the free-wheeling current to the current drivable means. As a result a portion of the stored energy in the energisable means - for example a motor winding - is used. The method steps may be carried out during an initial start-up phase of the machine.

[0018] Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:

Fig. 1 shows a schematic view of a typical, 3-phase switched reluctance machine;
Fig. 2 shows a prior art rotor position transducer for a switched reluctance machine;
Fig. 3 shows a conventional supply for a slotted optical switch;
Fig. 4 shows a conventional power converter circuit for one phase of a switched reluctance drive;
Fig. 5 shows a power converter circuit according to the present invention;
Fig. 6a shows a typical winding current profile for one phase of a switched reluctance machine when the machine is in the chopping mode;
Fig. 6b shows the current profile for a zener diode corresponding to the winding current of Fig. 6a in an embodiment of the invention;
Fig. 6c shows the time scale for the current profiles of Figs. 6a and 6b;
Fig. 6d shows the LED supply voltage;
Fig. 7a shows a typical winding current profile for one phase of a switched reluctance machine when the machine is in the single-phase mode;
Fig. 7b shows the zener diode current profile corresponding to Fig. 7a;
Fig. 7c shows the LED supply voltage; and
Fig. 8 shows a power converter circuit according to another embodiment of the present invention.

[0019] The present invention solves the problems associated with the prior art arrangements by using a proportion of the stored energy in the motor winding that would either circulate in the free wheel loop or return to the DC bus during the energy return phase of operation of an SR machine to power the LED.

[0020] Fig. 4 shows a conventional "two switch per phase" power converter circuit for one phase winding 20 of a switched reluctance motor. The circuit comprises the phase winding 20 in series with a "top" switch 28 and a "bottom" switch 24 connected across the dc link. A current measurement resistor 30 may be included, typically adjacent to the OV rail, to provide a low-cost method for measuring current. Diodes 22 and 26 are connected between the ends of the phase winding and the opposite rail of the DC link. When both switches 28 and 24 are closed, voltage is applied to the phase winding. Flux, which is the time integral of the applied voltage, begins to increase in the magnetic circuit associated with the phase winding, and current is drawn from the supply to support this flux. If both switches are opened together, the current continues to flow, but now through the diodes and back to the dc link. The action of the diodes is to reverse the voltage across the winding, so the flux (and hence the current) decay to zero. This decay is commonly referred to as the "energy return" part of the cycle. If, however, one switch (say 28) is opened ahead of the other, the only voltage applied across the winding is that comprising the resistive voltage drop across the winding and resistor 30 and the conduction voltage drop in the switch 24 and diode 26. Since this voltage is small, the flux decays very slowly and hence the current also decays slowly as it circulates around the loop formed by the winding 20, switch 24, resistor 30 and diode 26. This circulation is commonly referred to as "free wheeling" and can be used for a variety of reasons, including control flexibility, acoustic noise reduction, etc. all as known in the art. Switches 24,28 can, for example, be power transistors, such as bipolar transistors, insulated gate field effect transistors, power metal oxide silicon field effect transistors etc., controlled by any one of a large number of known methods.

[0021] Other conventional power convertor circuits are known from the document 'Unipolar convertors for switched reluctance motors; conference record of the Industry Application Society annual meeting (IAS), San Diego, Oct. 1-5, 1989, vol. part 1, no. conf 24 1 October 1989, pages 551-560.

[0022] Fig. 5 shows a power converter circuit according to the invention in which components additional to Fig. 4 have been incorporated to provide a power supply for the LED 12.

[0023] Referring to Fig. 6a, a typical winding current profile obtainable using the circuit of Fig. 4 for the phase winding 20 is shown. In a first step, the winding 20 is energised rapidly to the value, for example, of 4A by closing both switches 24 and 28 to establish a direct current path through the winding 20 from the positive voltage line to the zero volt line. As can be seen from Fig. 6a the current, i_w, rises rapidly to the 4A value. In order to approximate a square pulse of current, the current is then "chopped". The chopping operation comprises repeatedly opening and closing one or other of the switches 24,28 - for example switch 28. When the switch 28 is open, current flowing in the winding 20 continues to circulate in the free-wheeling path through the closed switch 24 and the diode 26 in a "zero voltage" loop. As can be seen from the current curve in Fig. 6a the current i_w decays slowly. When the switch 28 is closed once again the current rises rapidly to the previous 4A value at which point the switch 28 is opened once more. It can be seen that by repeating these steps the profile shown in Fig. 6a is achieved. This chopping operation allows the current to be maintained at an average level for a desired period of time during which the winding 20 is energised. To de-energise the winding 20, both switches 24 and 28 are opened and the current is compelled to flow through both diodes 22,26 and decays rapidly, returning the energy to the supply.

[0024] Referring now to Fig. 5, the circuit according to an embodiment of the present invention allows a proportion of the energy in the winding 20 to power the LED 12 during energy return of free-wheeling portions of the cycle. Where appropriate, similar reference numerals have been used as in Fig. 4. In addition to the LED 12, the circuit includes various additional components as described in more detail below connected between the second diode 26 and the zero volt line.

[0025] The additional components include a zener diode 40 (in this example, rated at 5V) connected between the second diode 26 and the zero volt supply line. Also connected between the second diode 26 and the zero volt supply line, in parallel with the zener diode 40, is a series combination of a resistor R1 (in this example 10 ohms) and a capacitor C. The LED 12 and a resistor R2 (in this example 220 ohms) in series therewith are also connected between resistor R1 and the zero volt supply line in parallel with the capacitor C. The value of the capacitor C in this example is 1000μF.

[0026] In operation, when both switches 24,28 are closed and current in the winding 20 rises rapidly, diode 26 prevents current from flowing through the LED and associated components. When switch 28 is opened, the current flows in the free-wheeling state through resistor 30 and diode 26. The zener diode 40 is reverse biased and thus holds the voltage at a point between the zener diode 40 and the second diode 26 at the constant value, in the present example 5V. Capacitor C is thus charged to that value through resistor R1 and current simultaneously runs through LED 12 via resistors R1 and R2 such that the LED 12 operates at the desired current level. When switch 28 is closed once again the current through the zener diode and diode 26 drops to zero. The capacitor C, however, acts as a hold-up capacitor which partially discharges across the LED and maintains the LED current.

[0027] Operation of the circuit can be best understood from the waveforms shown in Figs. 6b to 6d, where, as discussed above, the winding current profile is shown in Fig. 6a. The corresponding zener diode current, i_z, is shown in Fig. 6b. For the sake of illustration, it is assumed that the zener diode is ideal (i.e., it has no leakage current) and the capacitor is ideal. When both switches 24,28 are closed and the winding current rises to 4A, the zener diode current is zero. At the first chopping step when switch 28 is opened, the zener diode current jumps to 4A and then decays slowly. The zener diode current drops to zero when the switch 28 is closed once again and the winding current rises, and the pattern repeats at the next chopping step. When both switches 24,28 are opened, at point M, and the current through the winding 20 begins to decay rapidly through diodes 22 and 26 and the zener diode.

[0028] The on-off period of the winding current pulse is shown in the example of Fig. 6C as being on for 4ms and off for 8ms so that the zener diode 40 conducts for almost $^1/_3$ of the time. The corresponding LED supply voltage, V_c, is shown in Fig. 6d. As can be seen, the LED supply voltage is maintained substantially at the maximum value of 5V whilst the winding is energised, the hold-up capacitor C maintaining the LED supply voltage when the zener diode current drops to zero briefly during chopping. When the winding 20 is de-energised and the zener diode current drops to zero, the LED supply voltage decays only slowly because of the capacitor C. For example, where a value of 1000μF is used for the capacitor, the supply voltage drops by approximately 0.2V before the winding is energised again. It will be seen, therefore, that once the motor is in operation, the LED supply voltage is maintained at substantially 5V.

[0029] It will be understood by the skilled person that the main function of resistor R1 in Figure 5 is to limit the initial surge of current into the capacitor. If the capacitor is of sufficient rating, then R1 may be omitted. However it will generally be found that the incorporation of R1 is cost-effective in that it allows a significant reduction in the cost of the capacitor.

[0030] On start-up of the motor, to prime the system and provide current to the LED 12 before the motor begins to operate, it is necessary to energise the motor winding 20. Various arrangements are known for priming the system. For example, referring to US 5,539,293, in systems employing a coded position sensor arrangement a starting sequence is used to locate the rotor in a known position by energising selected stator poles to orientate the rotor into the predetermined position. The energising current used in such systems can be used to provide current to the LED 12 before the motor begins operation. Alternatively, the winding 20 can be energised with a low level of current which produces negligible torque in the motor. Once the priming sequence has established the required current to the LED 12, the motor can now operate conventionally, the current to the LED 12 being maintained by periodically topping up the reservoir capacitor each time the winding is being de-energised as discussed above. The system can also be used to provide a negative supply voltage (as a result of the bias of the zener diode) for any circuit that may require it,for example,analogue comparators. The connection 44 in Figure 5 shows where such other circuits could be connected.

[0031] The winding current profile shown in Fig. 6a is typical, for example, of a washing machine drive operating at medium speed, e.g., in wash mode. Figs. 7a to 7c show operation at high speed, in which the zener diode 40 conducts for approximately 33% of the time. Once again when both switches 24,28 are closed, energising the winding 20 as shown in Fig. 7a, the zener diode current, i_z, shown in Fig. 7b remains at zero. In this mode no chopping takes place and switches 24,28 are simply opened again once the desired rotor position is reached and the winding current decays to zero once more. In the embodiment shown, the winding is energised for approximately 0.2ms and the current decays to zero once more in an equal period of 0.2ms. The winding current remains at zero for a further 0.2ms before the winding 20 is re-energised. As can be seen from Fig. 7b the zener diode current switches on after 0.2ms and decays with the winding current back down to zero after a further 0.2ms. The zener diode voltage is maintained at a constant 5V while current flows in the zener diode. Referring to Fig.7c the LED supply voltage (V_C) is maintained at 5V whilst current flows through the zener diode 40 and decays slowly when the zener diode current is zero because of the capacitor C until current flows once again through the zener diode 40. Once again for a capacitance of 1000μF, the voltage decays by approximately 8mV whilst the zener diode current is zero, remaining therefore at a sufficient level to maintain suitable current flow through the LED 12.

[0032] While the operation of the circuits has been described in association with modes of control in which the current in the phase winding 20 falls to zero during its cycle, it is also possible to implement the invention on systems where the current does not fall to zero during the cycle, e.g. as described in EP 0534761 B1.

[0033] The value of the hold-up capacitor C can be reduced using the circuit shown in Fig. 8. A 3-phase motor is shown including windings 20a, 20b and 20c. In addition to respective conventional components (diodes 22a,b,c and 26a,b,c, switches 24a,b,c and 28a,b,c and resistors 30a,b,c corresponding to the arrangement shown in Fig. 4), each winding 20a,b,c is also associated with a respective zener diode 40a,b,c and resistor R1a,b,c. Each of the phases is connected via R1 to a common LED 12, resistor R2 and parallel capacitor C such that the current in each winding 20a,b,c is used in turn to power the LED 12. As a result, the capacitor C need only be of a high enough value to maintain the LED at a suitable voltage during chopping in each phase and need not sustain a suitable voltage for the time during which a given phase is off. Of course this system is achieved at the expense of additional components such as the zener diodes 40b,c and the resistors R1b,c. Further diodes 50a,b,c are connected between each resistor R1a,b,c and the resistor R2 and capacitor C to prevent current flow between windings 20a,b,c.

[0034] It will be appreciated that whilst the above system has been discussed with reference to a switched reluctance motor it would be equally appropriate for a generator or indeed any suitable electric machine having energisable windings and requiring a power supply for another circuit.

[0035] It will further be appreciated that the zener diode 40 and capacitor C arrangement discussed above could be replaced by any appropriate circuitry. The particular effect of the zener diode 40 is that it maintains constant the voltage across the LED 12 and resistors R1 and R2, allowing controllable constant current flow through the LED. The particular effect of the capacitor C is that of holding the voltage substantially constant at these times where the zener diode 40 is off.

[0036] While the invention has been described in connection with the illustrative embodiments discussed above, those skilled in the art will recognise that many variations may be made without departing from the present invention. For example, the present invention is applicable to inverted machines in which the stator is in the centre of the machine and the rotor is arranged to rotate around the outside of the stator. Also, the invention is applicable to linear machines as well as rotary ones. The term rotor is often used in relation to linear machines to describe the moving member. The term rotor used herein is intended to embrace such moving members of linear machines.

[0037] Although the above discussion relates to the provision of current to an LED in a RPT, it will be appreciated that other current drivable components could be driven using a proportion of the stored energy in the motor winding.

[0038] Accordingly, the above description of several embodiments is made by way of example and not for the purposes of limitation. The present invention is intended to be limited only by the scope of the following claims.

Claims

1. An electric machine comprising a stator part and a moving part, current energisable means (20) provided on one or other part, which means are energisable to drive the moving part relative to the stator part, a first circuit, including the current energisable means and voltage setting means (40) arranged in a common current path with the current energisable means, whereby current flows in said first circuit during operation of the electric machine, **characterised in that** the electric machine further comprises another circuit powered by said first circuit at a substantially constant voltage (V_Z) developed across it by the voltage setting means.

2. An electric machine as claimed in claim 1 in which the other circuit comprises all or an element (12) of a position sensor (10) for sensing the position of the moving part relative to the stator part.

3. An electric machine as claimed in claim 1 in which voltage maintaining means (C) are provided in parallel with the voltage setting means.

4. An electric machine as claimed in claim 1, 2 or 3 in which the voltage setting means comprise a zener diode (40).

5. An electric machine as claimed in claim 3 in which the voltage maintaining means comprise a capacitor (C) or a capacitor and resistor (R1) in series.

6. An electric machine as claimed in any preceding claim comprising a multi-phase electric machine having a respective current energisable means (20a;b;c) associated with each phase, wherein the voltage setting means (40a;b;c) are provided in a common current path with each current energisable means.

7. An electric machine as claimed in any of claims 1 to 6, including a two-switch-per-phase switch circuit which is configurable into a freewheel loop including the current energisable means and the voltage setting means.

8. A method of providing current to another circuit in an electric machine, the electric machine comprising a stator part and a moving part and current energisable means (20) associated with one or other parts energisable to drive the moving part relative to the stator part, the current energisable means being part of a first circuit together with voltage setting means (40) arranged in a common current path therewith, whereby current flows in the first circuit during operation of the electric machine, the method being **characterised by**:

> powering the other circuit by the first circuit at a substantially constant voltage (V_z) developed across it by the voltage setting means.

9. A method as claimed in claim 8 in which the other circuit comprises all or an element (12) of a position sensor (10) for sensing the position of the moving part relative to the stator part.

10. A method as claimed in claim 8 or 9 further comprising switching the current energisable means to a free-wheeling state and deriving the power from the free-wheeling current for the other circuit.

11. A method as claimed in any of claims 8 to 10 in which the power is derived during an initial start-up phase of the machine.

Patentansprüche

1. Elektrische Maschine, mit einem Statorteil und einem bewegten Teil, durch Strom erregbare Mittel (20), welche an dem einen oder dem anderen Teil vorgesehen sind, wobei die Mittel erregbar sind, um den bewegten Teil relativ zum Statorteil anzutreiben, einen ersten Kreis, der die durch Strom erregbaren Mittel und Spannungseinstellmittel (40) enthält, welche in einem gemeinsamen Strompfad mit den durch Strom erregbaren Mitteln angeordnet sind, wobei beim Betrieb der elektrischen Maschine Strom in dem ersten Kreis fließt, **dadurch gekennzeichnet, daß** die elektrische Maschine des weiteren einen anderen Kreis enthält, welcher durch den ersten Kreis mit einer im wesentlichen konstanten Spannung (V_z) gespeist wird, die in diesem durch die Spannungseinstellmittel herbeigeführt wird.

2. Elektrische Maschine nach Anspruch 1, wobei der andere Kreis alle oder ein Element (12) eines Positionssensors (10) zum Erfassen der Position des bewegten Teils relativ zum Statorteil enthält.

3. Elektrische Maschine nach Anspruch 1, wobei Spannungserhaltungsmittel (C) parallel zu den Spannungseinstellmitteln vorgesehen sind.

4. Elektrische Maschine nach Anspruch 1, 2 oder 3, wobei die Spannungseinstellmittel eine Zener-Diode (40) enthalten.

5. Elektrische Maschine nach Anspruch 3, wobei die Spannungserhaltungsmittel einen Kondensator (C) oder einen in Serie geschalteten Kondensator und Widerstand (R1) enthalten.

6. Elektrische Maschine nach einem der vorangehenden Ansprüche, umfassend eine mehrphasige elektrische Maschine, welche entsprechende durch Strom erregbare Mittel (20a;b;c) aufweist, die der jeweiligen Phase zugeordnet sind, wobei die Spannungseinstellmittel (40a;b;c) in einem gemeinsamen Strompfad mit jedem durch Strom erregbaren Mittel vorgesehen sind.

7. Elektrische Maschine nach einem der Ansprüche 1 bis 6, die einen Zwei-Schalter-pro-Phase-Schaltkreis aufweist, welcher zu einer Freilaufschleife konfiguriert werden kann, die die durch Strom erregbaren Mittel und die Spannungseinstellmittel enthält.

8. Verfahren zum Liefern von Strom an einen anderen Kreis in einer elektrischen Maschine, wobei die elektrische Maschine einen Statorteil und einen beweglichen Teil und durch Strom erregbare Mittel (20) aufweist, welche an dem einen Teil öder dem anderen Teil vorgesehen sind, wobei die Mittel erregbar sind, um den beweglichen Teil relativ zum Statorteil anzutreiben, wobei die durch Strom erregbaren Mittel Teil eines ersten Kreises sind, gemeinsam mit den Spannungseinstellmitteln (40), die in

einem gemeinsamen Strompfad damit angeordnet sind, wobei während des Betriebs der elektrischen Maschine Strom in dem ersten Kreis fließt, wobei das Verfahren **gekennzeichnet ist durch**:

> das Speisen des anderen Kreises **durch** den ersten Kreis mit einer im wesentlichen konstanten Spannung (V_z), welche **durch** die Spannungseinstellmittel in diesem herbeigeführt wird.

9. Verfahren nach Anspruch 8, wobei der andere Kreis alle oder ein Element (12) eines Positionssensors (10) zum Erfassen der Position des beweglichen Teils relativ zum Statorteil enthält.

10. Verfahren nach Anspruch 8 oder 9, weiters umfassend das Schalten der durch Strom erregbaren Mittel in einen Freilaufzustand und Ableiten des Stroms von dem Freilaufstrom für den anderen Kreis.

11. Verfahren nach einem der Ansprüche 8 bis 10, wobei der Strom während einer anfänglichen Hochfahrphase der Maschine abgeleitet wird.

Revendications

1. Machine électrique comprenant une partie fixe et une partie mobile, des moyens pouvant être excités par un courant (20) prévus sur l'une ou l'autre partie, lesquels moyens peuvent être excités pour entraîner la partie mobile par rapport à la partie fixe, un premier circuit, comprenant les moyens pouvant être excités par un courant et des moyens de fixation de tension (40) montés dans un trajet de courant commun avec les moyens pouvant être excités par un courant, de telle sorte que le courant circule dans ledit premier circuit pendant le fonctionnement de la machine électrique, **caractérisée en ce que** la machine électrique comprend en outre un autre circuit alimenté par ledit premier circuit à une tension pratiquement constante (V_2) développée à travers celui-ci par les moyens de fixation de tension.

2. Machine électrique suivant la revendication 1, dans laquelle l'autre circuit comprend la totalité ou un élément (12) d'un capteur de position (10) pour détecter la position de la partie mobile par rapport à la partie fixe.

3. Machine électrique suivant la revendication 1, dans laquelle des moyens de maintien de tension (C) sont prévus en parallèle aux moyens de fixation de tension.

4. Machine électrique suivant la revendication 1, 2 ou 3, dans laquelle les moyens de fixation de tension comprennent une diode Zener (40).

5. Machine électrique suivant la revendication 3, dans laquelle les moyens de maintien de tension comprennent un condensateur (C) ou un condensateur et une résistance (R1) en série.

6. Machine électrique suivant l'une quelconque des revendications précédentes, comprenant une machine électrique multiphasée comportant un moyen pouvant être excité par un courant respectif (20a;b;c) associé à chaque phase, de telle sorte que les moyens de fixation de tension (40a;b;c) sont prévus dans un trajet de courant commun avec chaque moyen pouvant être excité par un courant.

7. Machine électrique suivant l'une quelconque des revendications 1 à 6, comprenant un circuit de commutation à deux commutations par phase qui peut être configuré en une boucle de roue libre comportant les moyens pouvant être excités par un courant et les moyens de fixation de tension.

8. Procédé pour fournir un courant à un autre circuit dans une machine électrique, la machine électrique comprenant une partie fixe et une partie mobile et des moyens pouvant être excités par un courant (20) associés à l'une ou à d'autres parties pouvant être excités pour entraîner la partie mobile par rapport à la partie fixe, les moyens pouvant être excités par un courant faisant partie d'un premier circuit ainsi que les moyens de fixation de tension (40) montés dans un trajet de courant commun avec ceux-ci, de telle sorte que le courant circule dans le premier circuit pendant le fonctionnement de la machine électrique, le procédé étant **caractérisé par** :

> l'alimentation de l'autre circuit par le premier circuit à une tension pratiquement constante (V_2) développée à travers celui-ci par les moyens de fixation de tension.

9. Procédé suivant la revendication 8, dans lequel l'autre circuit comprend la totalité ou un élément (12) d'un capteur de position (10) pour détecter la position de la partie mobile par rapport à la partie fixe.

10. Procédé suivant la revendication 8 ou 9, comprenant en outre la commutation des moyens pouvant être excités par un courant vers un état de roue libre et la dérivation de l'alimentation du courant de roue libre pour l'autre circuit.

11. Procédé suivant l'une quelconque des revendications 8 à 10, dans lequel l'alimentation est dérivée pendant une phase de démarrage initiale de la machine.

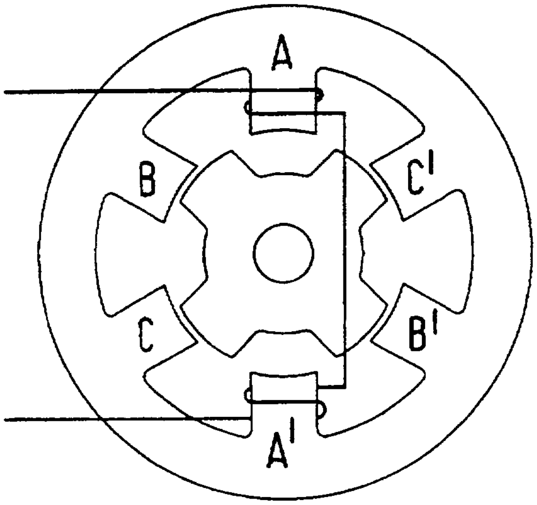

FIG.1
PRIOR ART

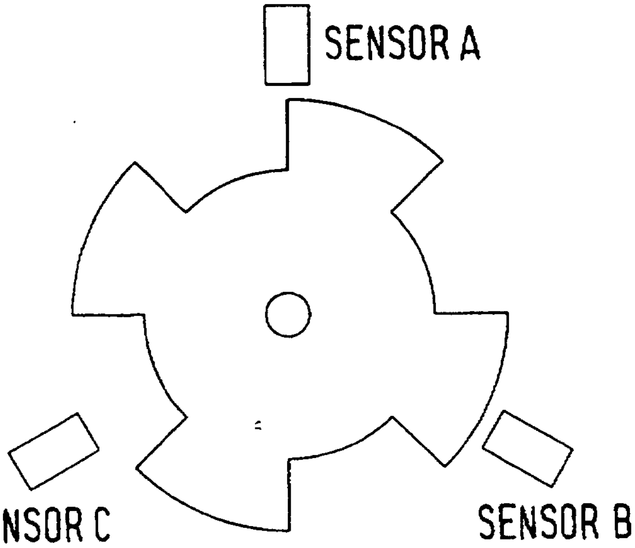

FIG. 2
PRIOR ART

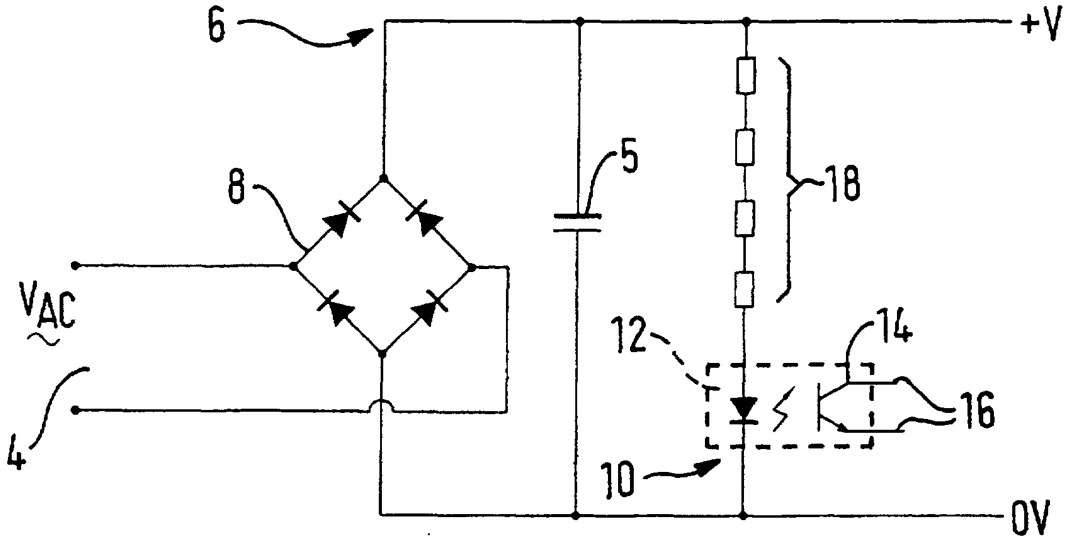

FIG. 3
PRIOR ART

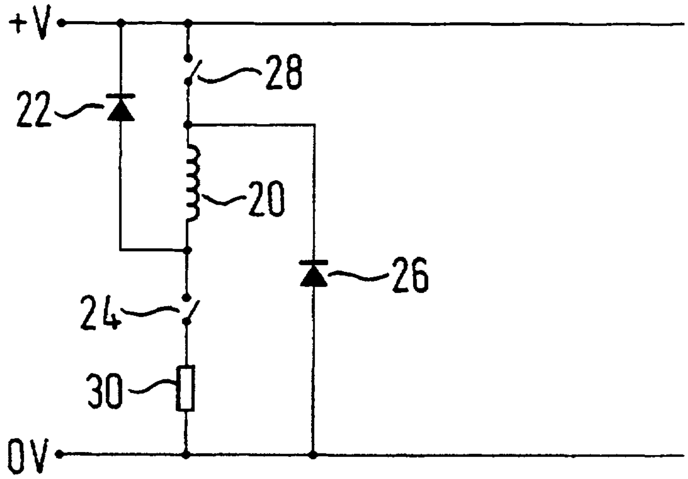

FIG. 4
PRIOR ART

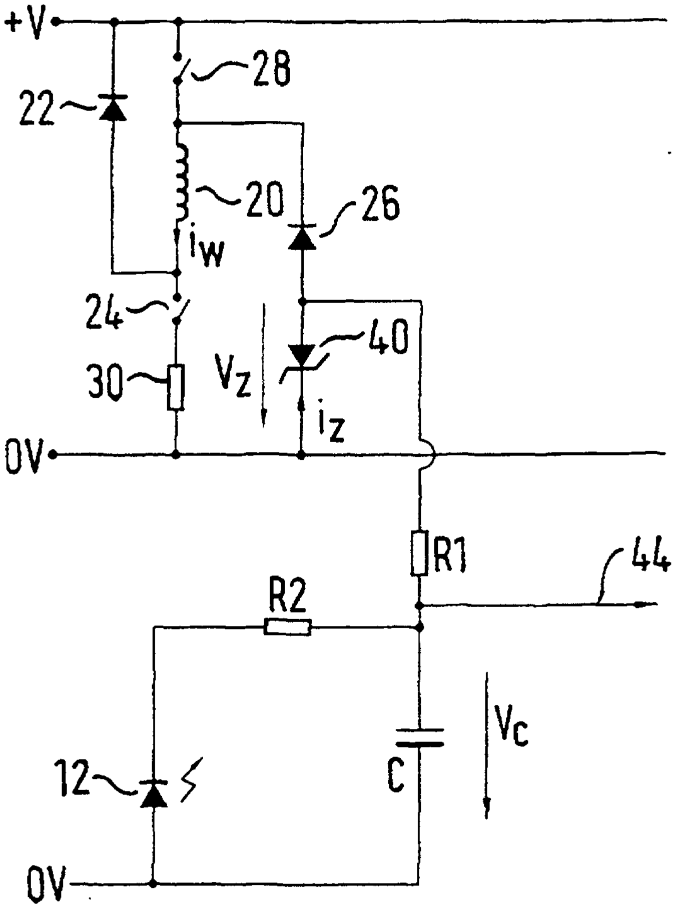

FIG. 5

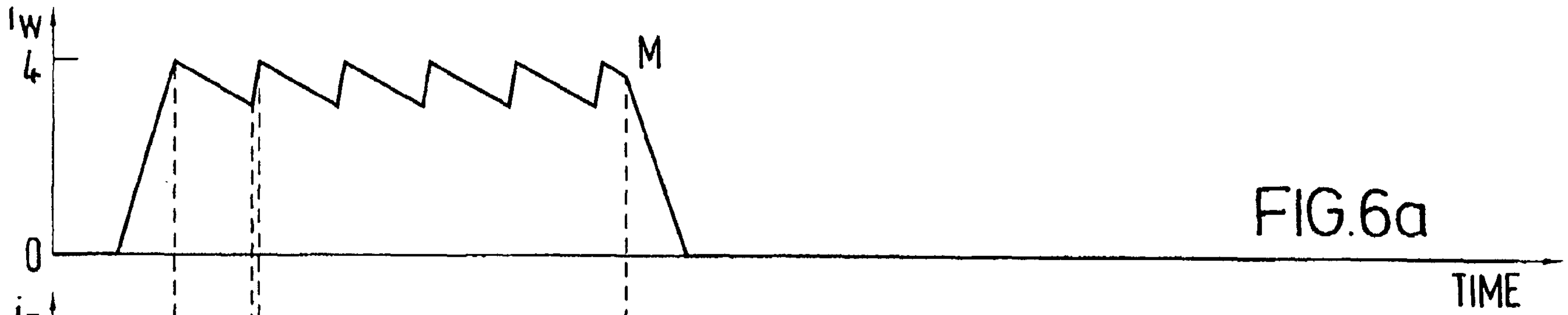

FIG.6a

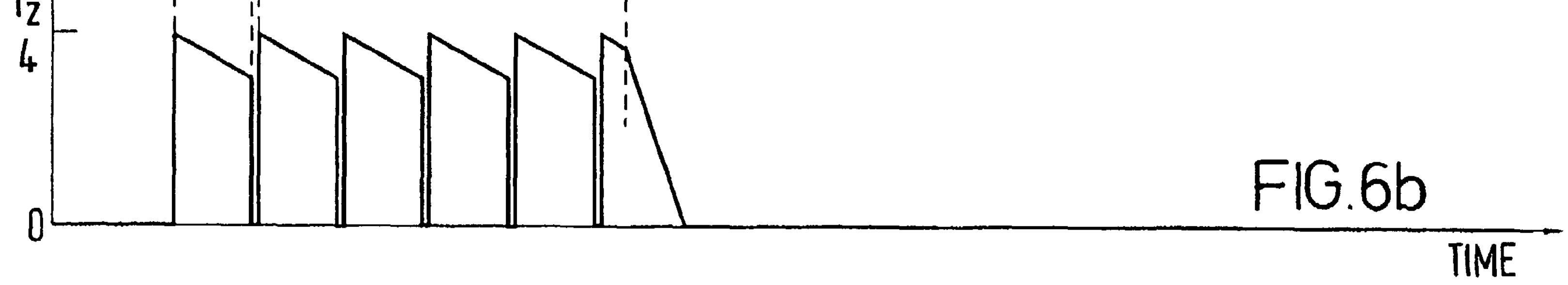

FIG.6b

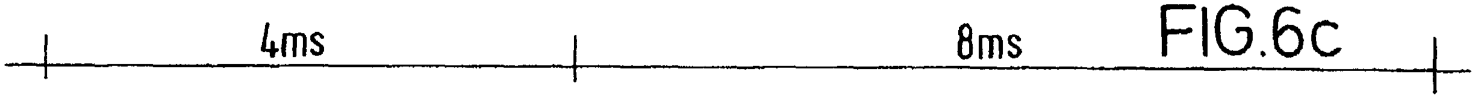

FIG.6c

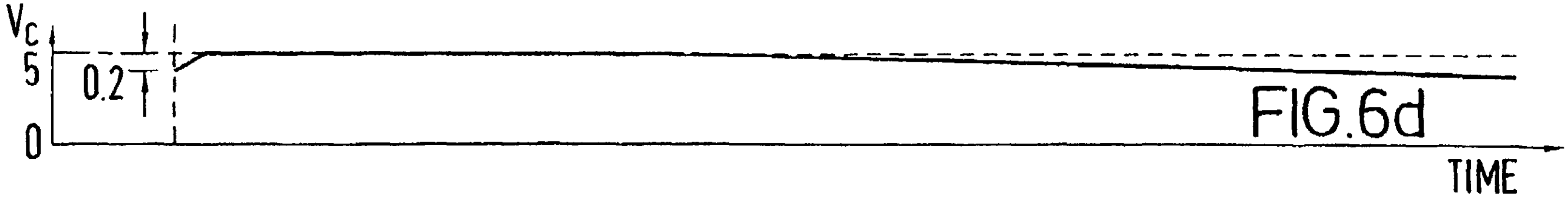

FIG.6d

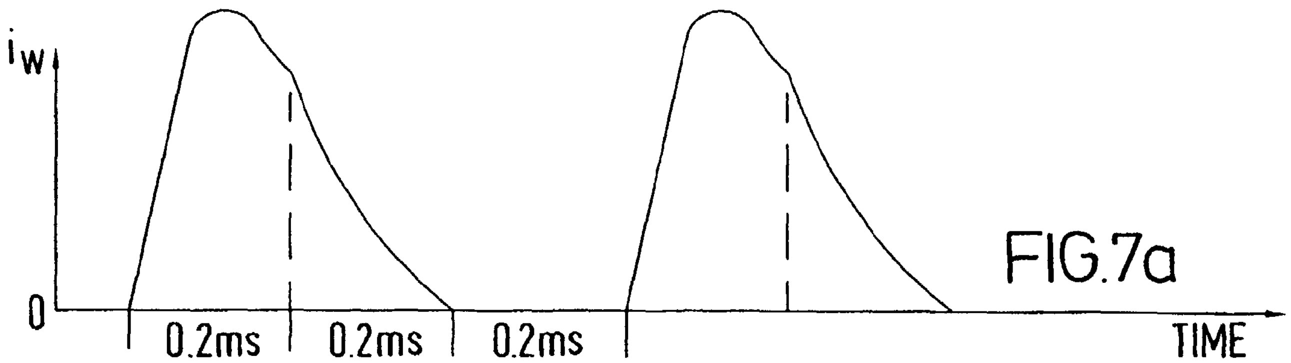

FIG.7a

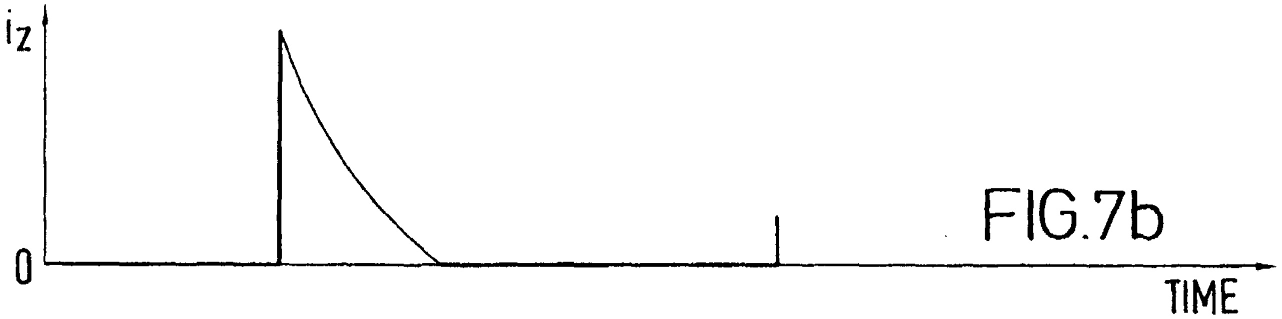

FIG.7b

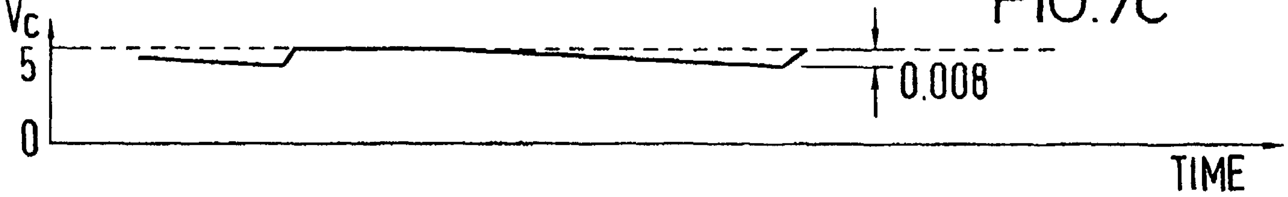

FIG.7c

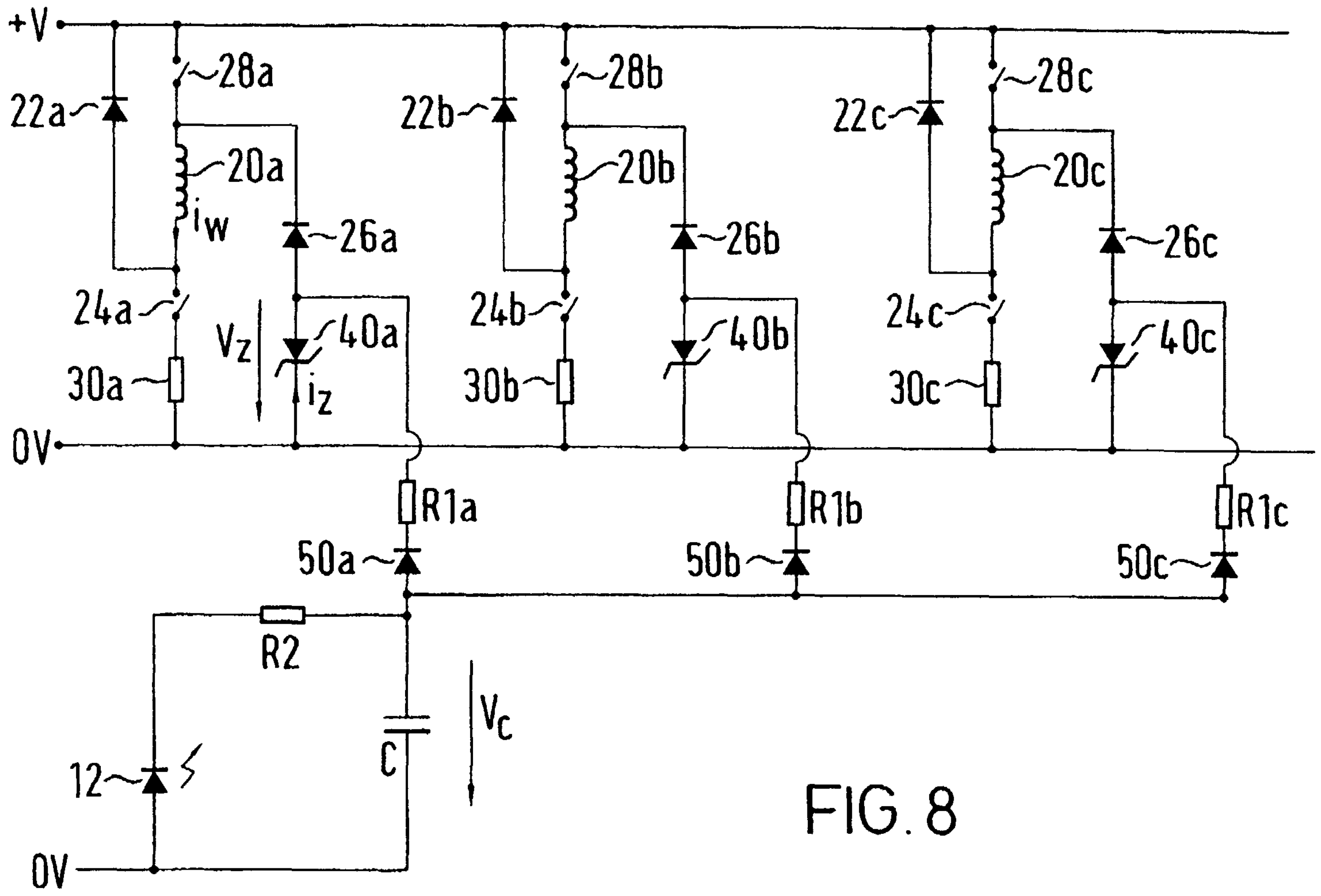
+V
i_w
V_z
i_z
0V
R1a
R1b
R1c
R2
C
V_c
0V

FIG. 8